Center Innovation Fund: SSC CIF

Optical Interferometry with Flexible Coherent Fiber Bundle for Measuring Deposits or Contamination on Surfaces and Inside Tubes

Completed Technology Project (2013 - 2014)

Project Introduction

A new measuring/cleaning method for closed surfaces (pipes) applicable to removing contaminants (oil films, fungus, rust) from NASA instruments and spacecraft is being proposed. This technique relies on a combination of a practical single-beam Holographic in-line interferometry (HILI) and Coherent fringe projection (CFP) techniques in one set-up with modification needed to work inside closed surfaces of tubes and pipes. Additionally, a unified approach for modeling of both HILI and CFP that is suitable for remote characterization of contaminants inside these structures is also being proposed. This modeling approach is based on the concept of the coherent superposition of partial interference patterns. Then, it will be shown that the combination of laser-induced fluorescence and laser induced optical trapping and evaporation may provide more accurate detection of contaminants and a new method of laser-induced cleaning of contamination. Based on previous experience with oil contamination, a modified version of fringe projection interferometry to monitor contamination in the pipes, which will include a flexible coherent optical fiber bundle to allow inspection of pipe's inner space will be used. Flexible coherent optical fiber bundle allow to transmit images of contaminated spots from the enclosed surface inside the pipes and tanks. Coherent fringe projection (CFP) techniques proved to be efficient in our previous efforts involving non-contact metrology of microstructured objects.

The contaminant removal from the pipes will be patterned along the lines of our previous work on removal of oil films from water. For cleaning of closed surfaces (pipes, tanks) flexible optical fibers will be used. Laser evaporated volatile fractions will be removed by air pumps and they may be condensed for further utilization.

The proposed efforts will develop the basis of an important tool, a tool that when fully developed will be extremely useful for NASA scientists in monitoring oil drilling related activities.

This project involves a demonstration for a new environmentally safe and accurate cleaning method for removing contaminants (oil films, fungi,) in enclosed areas such as pipes, tanks, and tubes. It relies on a combination of techniques such as, Laser-induced fluorescence (LIF), Optical trapping (OT), Holographic in-line interferometry (HILI), Coherent fringe projection (CFP), and Optical evaporation (OE). To enable inspection and operation of the method inside enclosed surfaces, the techniques will operate with a flexible coherent optical fiber bundle. A unified approach for modeling both HILI and CFP will be developed to demonstrate that these techniques are suitable for accurate remote characterization of contaminants.

Anticipated Benefits

The new measuring/cleaning method for closed surfaces (pipes) applicable to removing contaminants (oil films, fungus, rust) from NASA instruments and

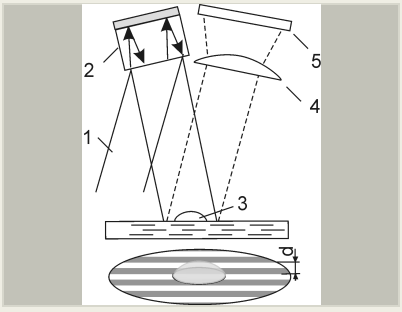

Illustration - Optical Interferometry

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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

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spacecraft, using optical interferometry with flexible coherent fiber bundle, directly benefits NASA funded missions by improving safety and reliability with improved inspection capability of test area and test article piping. Laser technology for non-contact measurement of contamination films and controlled clean-up of spacecraft surfaces and pipes inside the spacecraft would be enabled. Condensed molecular films are the most prevalent form of pollution in space. These films when exposed to solar ultraviolet light can also undergo polymerization which results in hardened surfaces that cannot be easily removed from surfaces and lenses. Elimination of fouling, rust, contaminants, and oil or grease that can get into pipes and tubes of sensors is usually performed using chemical or mechanical means that can damage the structures or contaminate clean rooms where sensors are built. Laser cleaning of pipes is a clean procedure highly desirable in sterile environments such as those required for optimum NASA sensor and aircraft operation.

The new measuring/cleaning method for closed surfaces (pipes) applicable to removing contaminants (oil films, fungus, rust) from NASA instruments and spacecraft, optical interferometry with flexible coherent fiber bundle, will improve safety and reliability with improved safety and reliability with improved inspection capability of test area and test article piping. Future iterations could potentially evolve into a capability inspecting flight hardware in-situ.

Benefits to the commercial space industry are comparable to those that benefit NASA, and could accordingly be used to improve inspection capability for use within a variety of enclosed surfaces that require non-contact film thickness measurements in pipes and surface cleaning.

The technology would benefit other government agencies like the EPA by better enabling them to assess the impact of a chemical spill. Further, government agencies could use the technology to investigate enclosed piping, vessels, and containers that are inaccessible, as part of the assessment process.

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Ramona E Travis

Project Manager:

Curtis D Armstrong

Principal Investigator:

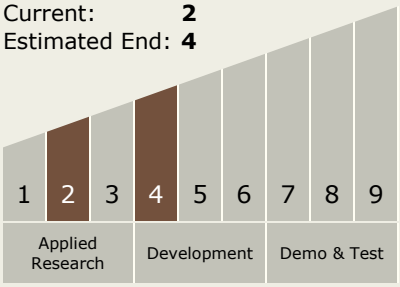
Curtis D Armstrong

Co-Investigators:

Tatiana Kukhtarev
Sonia C Gallegos
Nickolia Kukhtarev

Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **4**



Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - TX07.3 Mission Operations and Safety

Continued on following page.

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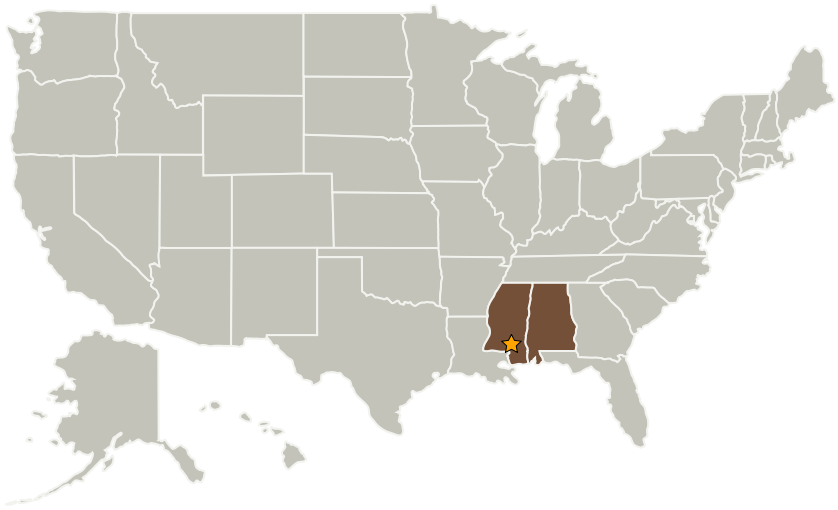
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi
Alabama A & M University	Supporting Organization	Academia	Normal, Alabama

Primary U.S. Work Locations	
Alabama	Mississippi

Technology Areas *(cont.)*

- TX07.3.5 Planetary Protection

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Images

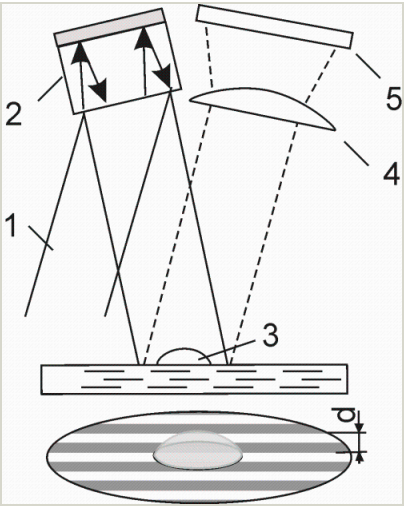

Illustration - Optical Interferometry
Illustration - Optical Interferometry *(https://techport.nasa.gov/image/2747)*